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Powering India's transition to renewable energy:
Battery energy storage system (BESS) pilot

India's transforming energy landscape, with its emphasis on renewable energy (RE), holds manifold promises for the country's enhanced energy security, reduced oil imports, and improved air quality. However, large-scale integration of variable RE also brings with it the significant challenge of ensuring that the power grid remain reliable and resilient even when absorbing varying and unpredictable energy from renewable sources such as sun and wind. Energy demand-supply mismatches must be addressed in real time to ensure grid reliability.

Battery energy storage system (BESS) — a technology for storing electric charges in specially developed batteries to enable the stored energy's utilization at a later time — is globally recognized as a powerful tool to manage the challenges associated with demand changes more efficiently. BESS allows energy to be stored when generation exceeds demand and to be released (or dispatched) when generation comes down and/or demand goes up. By increasing the system's overall flexibility, BESS can improve power quality and enhance the capacity of transmission grids, thereby ensuring uninterrupted power supply to distribution utilities. Put simply, energy storage can ensure power without interruptions.

BESS has gained significant popularity in western countries and holds promise for India's transitioning grid system. However, the technology's high capital cost and India's limited experience with it make investment decisions tough for both utilities and regulators. Integration of BESS technologies on a large scale warrants a robust understanding and testing of its commercial viability and technical feasibility.

> ***"I strongly believe that collaborative efforts by respective agencies will help the power sector grow progressively towards a transition, wherein the grid is more flexible, reliable, and efficient to foster and enhance renewable energy integration. We are proud to partner with USAID on this initiative and on our journey to a "high-performing, low-emission, energy-secure economy."***

Mritunjay Kumar Narayan
Joint Secretary (Transmission), Ministry of Power

The Greening the Grid-Renewable Integration Sustainable Energy (GTG-RISE) program, a joint initiative by USAID and India's Ministry of Power, has been testing solutions to enable large-scale RE integration in the national grid. GTG-RISE has implemented a series of prioritized innovation pilots to bolster national and regional power systems' ability to stay resilient while integrating RE. GTG-RISE is a key initiative under USAID's Asia Enhancing Growth and Development through Energy (EDGE) and is implemented by Deloitte Consulting LLP.

BUILDING EVIDENCE ON BESS DEPLOYMENT IN TRANSMISSION UTILITIES

To build evidence on the potential for BESS in India, USAID's Greening the Grid-Renewable Integration and Sustainable Energy (GTG-RISE) initiative conducted a four-year (2017–2020) pilot on the techno-economic feasibility of BESS in providing ancillary services (frequency reserves). Designed and implemented in close coordination with Power Grid Corporation of India Limited (POWERGRID), the pilot aimed to expand the understanding of the multiple benefits BESS can provide to grid operators and other stakeholders to fast-track large scale RE integration. Its specific objectives were to: demonstrate various possible use cases for BESS through enhanced IT-based controls, ascertain the feasibility of BESS in the grid, and assess the economic value of storage.

GTG-RISE conducted the pilot at POWERGRID's BESS facility at the 400/220 kV sub-station in Puducherry. The facility has two different battery technologies (lead-acid based and lithium-ion based) with a total installed capacity of 1 MW. The pilot entailed enhancing the existing IT-based controls at this BESS facility. In the original architecture, each of the two battery technologies had an independent power management system and separate supervisory control and data acquisition (SCADA) system. To ensure synchronized performance of the two battery technologies, the pilot designed a new architecture, introduced a common controller unit and modified the existing SCADA system to enable a common monitoring and operating platform for both battery technologies.

GTG-RISE also designed, developed, and tested six different BESS applications along with an integrated application mode. To demonstrate the BESS applications and their interaction with external parameters, meters were installed at a roof-top solar photo voltaic (PV) and 22 kV load site. Data exchange between these meters and the new control units was enabled over General Packet Radio Service (GPRS) through a cloud server.

A virtual event on December 21, 2020, marked the go-live launch of the BESS pilot at the Puducherry site. The closed-door virtual event, conducted jointly by USAID and POWERGRID, was attended by senior representatives from the Ministry of Power, Government of India; Power System Operation Corporation Limited (POSOCO); POWERGRID; USAID/India, and the GTG-RISE team.

Subsequent to the go-live event, the new system architecture and control logics for new BESS use cases/applications was subjected to rigorous testing over several months. After testing and system acceptance, a trial run of the BESS applications was carried out at the pilot site under actual grid conditions. During the trial run, all the BESS applications were tested for a sustained period, while critical system parameters were monitored and recorded along with battery performance.

Photo Credit - GTG RISE

Field visit to the pilot site for conducting pre-feasibility studies


Photo Credit - GTG RISE

Signing of MoU with POWERGRID

India's power systems are going for more efficient and better controls and processes to ensure the consumer is served economically. By 2025, we may require battery energy storage, and the USAID's BESS pilot outcomes will add value to our understanding and appreciation for storage systems' integration to the grid.

K V S Baba
CMD, POSOCO

PAVING THE WAY FOR A MORE SECURE GRID

GTG-RISE's BESS pilot successfully designed and demonstrated control logics for different BESS applications. The pilot installed the required hardware/software retrofits to enable real-time monitoring of grid parameters and specified controlled operation of BESS across the two battery technologies at POWERGRID's facility in Puducherry.

The various BESS use cases and applications can be harnessed by grid operators, as needed to meet grid requirements. Control logics developed for the BESS applications, such as 'dynamic frequency' and 'voltage support,' will allow BESS developers to provide ancillary services. Similarly, the 'load following' and 'peak load shaving' applications can prove useful for distribution system operators by helping them to manage their load effectively, avoiding deviation settlement mechanism (DSM) penalties, and deferring capital expenditure for network elements experiencing short-term overloading. The other two applications — 'RE time shift' and 'RE energy capacity firming'— can be used by RE developers deploying grid-scale solar/wind plants in RE rich states to improve their power scheduling to the grid as well as to take advantage of energy arbitrage opportunities. These control logics are detailed in the technical report on GTG website.

SCALING UP BESS DEPLOYMENT

Suitably deployed, BESS gives system operators a flexible, rapid-response resource to effectively manage generation and load variability. The BESS pilot's learning and use cases can serve as a guiding tool to enhance BESS deployment by system operators and RE generators in India. For system operators in ancillary services operations, BESS can provide services such as frequency regulations, voltage support, and black start. It should be noted that transacting these services will require a mature ancillary market, with appropriate mechanisms to reward ancillary services providers.

India's Central Electricity Regulatory Commission (CERC) recently notified the draft Ancillary Service Regulation 2021 to provide a mechanism for deployment and procurement of ancillary services in India. The draft regulation details the mechanism and estimation process for reserves, eligibility, deployment, procurement, selection, dispatch, and payment for secondary reserve ancillary services (SRAS) and tertiary reserve ancillary services (TRAS). Once implemented, the draft ancillary regulation will drive the deployment of large grid-scale energy storage facilities for commercial operations.

While implementation of the Ancillary Service Regulation will certainly create market-side demand for BESS, the GTG-RISE BESS pilot will pave the way for multiple applications and use cases that will bring down the overall cost for BESS in India, to make its use more economical. Outcomes from the pilot will also help drive clear policy decisions and regulations to scale-up BESS so that India can harness its full potential. Key pilot learnings have been captured in a detailed technical guidance note on the development of control logics for various BESS applications, retrofit requirements (both hardware and software), and system architecture design. The guidance note will help any entity interested in deploying grid-connected BESS to assess the investment required.

Photo Credit - GTG RISE

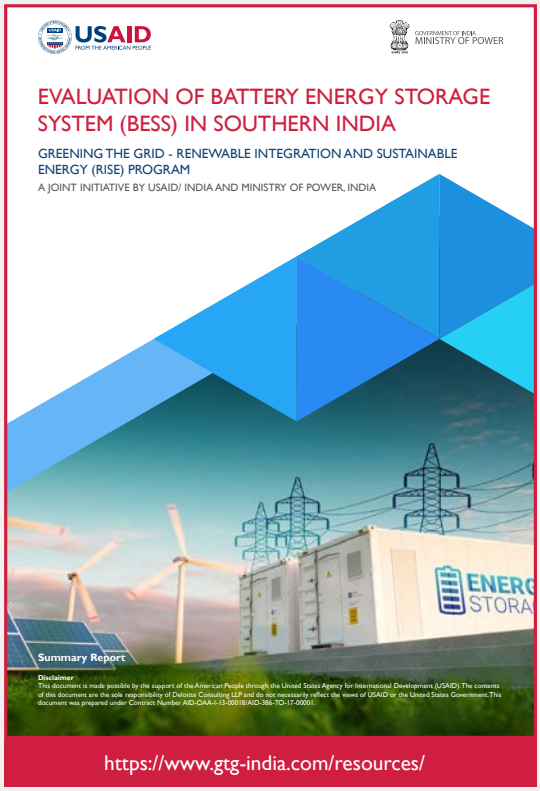
Go-live launch and BESS pilot demonstration at the Puducherry site, December 21, 2020,

The rate of growth of renewable energy in India is one of the highest in the world. With increased RE penetration, we need to ensure a reliable, flexible, and adaptive grid. The BESS pilot at our Puducherry facility is a first-of-its-kind initiative and will make a big contribution to our transitioning energy sector.

Dr. Subir Sen
Chief Operating Officer - CTU and Smart Grid, POWERGRID

EVALUATION OF BATTERY ENERGY STORAGE SYSTEM (BESS) IN SOUTHERN INDIA

In India, the CERC has provided a roadmap for operationalizing reserves. Per this roadmap, primary reserves are to be maintained at the all-India level, while each region must maintain secondary reserves corresponding to the largest unit size in the region. In the Southern region, the secondary reserve requirement would be 1,000 MW (*Central Electricity Regulatory Commission. December 2015. Roadmap to operationalize reserves in the country*). Aiming to build evidence on the potential of BESS, GTG-RISE initiative studied the techno-economic feasibility of BESS in providing ancillary services (frequency reserves) for the Southern region.



https://www.gtg-india.com/resources/

Scope of Study

GTG-RISE initiative conducted the study as part of its innovative pilot efforts aimed at supporting the Government of India in managing large-scale RE integration into the Indian power grid. The study on 'Evaluation of battery energy storage system for the Southern region' conducted a simulation-based modelling on the Southern region's network data to come up with the required frequency reserves for the Southern region. GTG-RISE carried out a detailed modelling assessment to gauge the BESS requirement for ancillary market operation. The study had two aims: i) to understand the required frequency reserves under primary and secondary reserves; and ii) to understand the role of BESS for these reserves. This study also conducted economic analysis to i) assess the benefits of centralized market operations in the day-ahead horizon; and ii) estimate the overall cost savings with and without the additional conventional capacity that might be released from primary reserves because of BESS deployment in such a market.

Study Results

Some of the key insights from GTG-RISE's techno - economic analysis of frequency reserves for the Southern region are highlighted below:

- BESS will help arrest the nadir frequency with its fast-response characteristics, as is the case with inertial support from conventional units and will also help achieve the target value for quasi steady state frequency. Thus BESS reduces the burden on conventional units due to high RE additions to the grid.
- BESS support in primary reserves can drastically reduce the primary reserves support required from conventional units for frequency reserves.
- If BESS is deployed to provide primary reserves, the reserve capacity of conventional units can be released to meet consumer/system demand.
- With 5% droop for conventional generation (as per IEGC guidelines) from the Southern region, about 3,000 MW of conventional capacity can be released for frequency reserves with BESS support.

Results from the Southern region study showed that by enabling BESS, primary support from conventional units can be limited to 331 MW instead of 3,274 MW—meaning that adding BESS capabilities can release 2,943 MW of power that can be used to meet consumer demand. Moreover, the study showed that deploying a 1,200 MW BESS system for INR 1,100 crore a year could save INR 3,000 crore a year due to additional capacity made available—estimated savings almost three times the cost.

The study's insights are compelling and can bolster efforts to secure the effectiveness and security of the Indian grid. Its outcomes will help Indian regulators to make evidence-based decisions on introducing regulatory pathways for grid connected BESS for ancillary services (frequency regulation).

Photo Credit - GTG RISE

The BESS pilot's outcomes have provided valuable insights for the policy and regulatory frameworks being developed in India to provide ancillary services or address network constraints. The pilot outcomes show what services BESS can provide and should help incentivize private sector engagement.

August 2021